IL NUOVO CIMENTO **39 C** (2016) 261
DOI 10.1393/ncc/i2016-16261-6

COLLOQUIA: IFAE 2015

A cylindrical GEM Inner Tracker for the BESIII experiment

A. AMOROSO(1)(2), R. BALDINI(3), M. BERTANI(3), D. BETTONI(4), F. BIANCHI(1)(2), A. CALCATERRA(3), V. CARASSITI(4), S. CERIONI(3), J. CHAI(1)(7), G. CIBINETTO(4), G. COTTO(1)(2), F. DE MORI(1)(2), M. DESTEFANIS(1)(2), J. DONG(3)(7), M. DONG(7), R. FARINELLI(4)(5), L. FAVA(1)(2), G. FELICI(3), E. FIORAVANTI(4), I. GARZIA(4), M. GATTA(3), M. GRECO(1)(2), J. F. HU(1)(2), T. JOHANSSON(8), C. LENG(1)(7), H. LI(1)(7), Z. LIU(7), M. MAGGIORA(1)(2), S. MARCELLO(1)(2), P. MARCINIEWSKI(8), M. MELCHIORRI(4), G. MEZZADRI(4)(5)(*), G. MORELLO(3), Q. OUYAN(7), S. PACETTI(6), P. PATTERI(3), A. RIVETTI(1), C. ROSNER(9), M. SAVRIÉ(4), S. SOSIO(1)(2), S. SPATARO(1)(2), E. TSKHADADZE(10), K. WANG(7), L. WANG(7), L. WU(7), X. JI(7), M. YE(7), A. ZALLO(3), Y. ZHANG(7) and L. ZOTTI(1)(2)

(1) *INFN, Sezione di Torino - Torino, Italy*
(2) *Università di Torino - Torino, Italy*
(3) *LNF-INFN - Frascati (RM), Italy*
(4) *INFN, Sezione di Ferrara - Ferrara, Italy*
(5) *Università di Ferrara - Ferrara, Italy*
(6) *INFN and University of Perugia - Perugia, Italy*
(7) *Institute of High Energy Physics - Beijing, PRC*
(8) *Uppsala University - Uppsala, Sweden*
(9) *University of Mainz - Mainz, Germany*
(10) *Joint Institute for Nuclear Research - Dubna, Russia*

received 7 January 2016

Summary. — We are developing a cylindrical GEM detector with analog readout to upgrade the Inner Tracker of the BESIII experiment at IHEP (Beijing). The new detector will match the requirements for momentum resolution ($\sigma_{p_t}/p_t \sim 0.5\%$ at 1 GeV) and radial resolution ($\sigma_{xy} \sim 100\,\mu$m) of the existing drift chamber and will improve significantly the spatial resolution along the beam direction ($\sigma_z \sim 150\,\mu$m) with very small material budget (about 1% of X_0). A beam test has been performed at CERN in order to measure the performance of a BESIII GEM prototype in a magnetic field up to 1 tesla. An overview of the project and the preliminary results of the test will be presented in the talk. The project has been recognised as a Significant Research Project within the Executive Programme for Scientific and Technological Cooperation between Italy and PRC for the years 2013–2015, and more recently has been selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.

(*) E-mail: `gmezzadr@fe.infn.it`

1. – Introduction

BESIII is a multiporpouse detector hosted in Beijing, PRC. It detects the collision provided by the BEPCII, a circular lepton collider with design luminosity of $10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, located at the IHEP of Beijing [1].

Going from the beam pipe to the outside, BESIII is composed by a Multilayer Drift Chamber (MDC), Time-Of-Flight (TOF) detectors, a CsI(Tl) electromagnetic calorimeter (EMC), a superconductive magnet and Resistive Plate Chambers (RPC) to detect muons and neutral hadron [2].

Due to the unprecedent luminosity reached by BEPCII and to the high radiation absorbed, the Inner Tracker is showing aging effects. Since BESIII wants to take data until 2022 and more likely to 2024, it will be necessary soon to upgrade the Inner Tracker with a new chamber.

2. – The BESIII CGEM-IT project

We proposed to build a new inner tracker based on Cylindrical Gas Electron Multiplier (CGEM) detector. It will be composed by three layers. Each one will be assembled with five cylindrical structures: one cathode, three GEMs [3] and the anode readout.

To match the requirements given by the BESIII Collaboration in terms of budget materials, a new Rohacell [4] based technique will be adopted to manufacture the anode and the cathode structure. An analogue readout is chosen as compromise between number of channels and desired spatial resolution within the BESIII 1 tesla magnetic field. The position will be identified with the charge centroid with a moderate strip pitch ($650\,\mu$m). The X strips, parallel with the CGEM-IT axis, will give information of the $r\phi$ coordinates, while the V strips, that have a stereo angle with respect to the X, can provide, together with the other view, the z coordinate. To reduce the inter-strip capacitance, a jagged-strip layout for the anode will be implemented.

3. – The test beam

A test beam was performed in Dec 2014 to test a $10 \times 10\,\mathrm{cm}^2$ BESIII-GEM planar prototype. The chamber had 128 readable channel both in X and Y view. Each side was acquired with an APV25 hybrid board [5]. The trigger system was made by the coincidence of four plastic scintillator. For the forward and the backward tracking systems four $10\times10\,\mathrm{cm}^2$ GEM chambers were used. All the scintillator and the chambers (trackers and prototype) were installed under the GOLIATH magnet, that is able to provide a magnetic field up to 1.5 tesla.

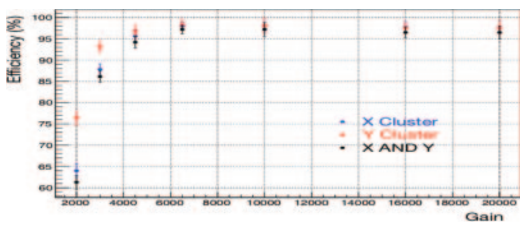

Fig. 1. – Study of the efficiency of the chamber as a function of the gas gain.

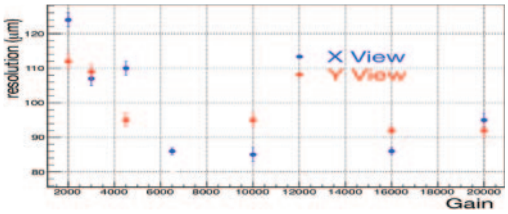

Fig. 2. – Study of the spatial resolution of the chamber as a function of the gas gain.

Different measurements were performed during the test beam. To understand the behaviours of the prototype with different geometries and gas mixtures, and to validate the analogue readout and the simulations, scan of gain, magnetic field and angle were performed.

The behaviour of the prototype was tested with and without magnetic field. The results shown in this work are extracted using a ArC_4H_{10} (90/10) gas mixture.

In fig. 1 a study of the efficiency of the test chamber with no magnetic field is presented. The efficiency is estimated as the ratio between the number of events in which a cluster is formed in the prototype and in the trackers and the number of events with a cluster in all four trackers. It is shown that the efficiency plateau is formed starting from a gain of 6500 both in a cluster in single view (X or Y) and in both view (XY) simultaneously. The plateau is around 97%. Figure 2 shows the spatial resolution of the chamber. It has evaluated preliminarly from the residual distribution of the chamber cluster with respect to the reconstructed ones. The results with zero magnetic field shows an average resolution around $\sigma = 90\,\mu$m.

4. – Summary

A brief overview of the CGEM-IT project was provided. The encouraging results need to be confirmed in a new test beam, that will be performed in June 2015 in order to fully understand the behaviour of the chamber also in the magnetic field.

The project has been funded within the Executive Programme for Scientific and Technological Cooperation between Italy and PRC for the years 2013–2015, and with the acronym BESIIICGEM has been selected as one of the project funded by the European Commission with the call H2020-MSCA-RISE-2014.

REFERENCES

[1] Asner D.M. *et al.*, *Physics at BES-III* arXiv:0809.1869.
[2] Ablikim M. *et al.* (BESIII Collaboration), *Nucl. Instrum. Methods Phys. Res. A*, **598** (2009) 711.
[3] Sauli F., *Nucl. Instrum. Methods Phys. Res. A*, **386** (1997) 531.
[4] `http://www.rohacell.com/product/rohacell/en/about/properties/pages/default.aspx`.
[5] Raymond M. *et al.*, *IEEE Nucl. Sci. Symp. Conf. Rec.*, **2** (2000) 9/113.